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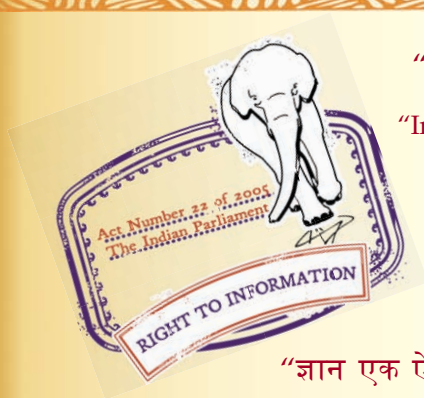
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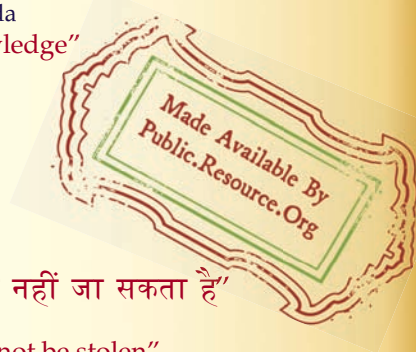
IS 4433 (1979): Method for Determination of Hardgrove Grindability Index of Coal [PCD 7: Solid Mineral Fuels]



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Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

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Indian Standard
METHOD FOR
DETERMINATION OF HARDGROVE
GRINDABILITY INDEX OF COAL
(*First Revision*)

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NEW DELHI 110002

Indian Standard

METHOD FOR DETERMINATION OF HARDGROVE GRINDABILITY INDEX OF COAL

(First Revision)

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Indian Standard
**METHOD FOR
DETERMINATION OF HARDGROVE
GRINDABILITY INDEX OF COAL**
(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 15 April 1979, after the draft finalized by the Solid Mineral Fuels Sectional Committee had been approved by the Petroleum, Coal and Related Products Division Council.

0.2 This standard was first published in 1967. However, in the course of time, with the use of Hardgrove grindability machines on a wider scale, necessity was felt to revise the standard.

0.3 In the present revision a standard table for ascertaining the values of Hardgrove Grindability Index (HGI) from the experimental values of mass of the coal particles over 75-micron sieve has been introduced. Minor modifications have also been made in the diameter of the steel balls used between the grinding bowl and ring to align the dimension with that given in DP 5074 'Hard coal determination of Hardgrove Grindability Index' issued by the International Organization for Standardization.

0.4 The grindability of coal is a measure of the ease with which it can be ground fine enough for use as a pulverized fuel, and as such it reflects some of the physical properties of coal, like hardness, strength, tenacity, and fracture. Of the two methods developed for determining grindability of coals, that developed by R. N. Hardgrove is better known and is simpler. The Hardgrove grindability test serves as a means for estimating how various coals behave in the commercial pulverizers. This method is based upon the relative ease of grinding in a batch machine where the grinding is stopped before appreciable cushioning from finely crushed material occurs. The relation between grindability and capacity of any pulverizer is a straight line if plotted on a graph provided fines are removed from the pulverizing zone before the cushioning effect becomes dominant.

0.5 A general relationship exists between grindability of coal and its rank as shown by the degree of metamorphism in the natural series from brown coals and lignites to anthracite. Coals that are easiest to grind (having highest grindability index) are those of about 14 to 30 percent volatile matter content on the dry, mineral-matter-free basis. Coals of either lower or higher volatile content (the brown coals and lignites are exception) are more difficult to grind. However, the relation between the grindability and the rank is not sufficiently precise for grindability to be estimated from the chemical analysis of a coal with acceptable accuracy. Petrographic and mineral constituents influence grindability.

0.6 The Hardgrove grindability index of coal is affected by its moisture content and thus on the relative humidity of the atmosphere in which the sample was stabilized before the test and in which the test is carried out. However, even in case of high moisture coals, the difference of Hardgrove index due to that factor is not significant.

0.7 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

1. SCOPE

1.1 This standard prescribes the method for determining the grindability index of all types of Indian coals, excepting brown coals and lignites, using the Hardgrove machine.

2. TERMINOLOGY

2.1 For the purpose of this standard the definitions given in IS : 3810 (Part I)-1978† and IS : 3810 (Part II)-1978‡ shall apply.

3. PRINCIPLE

3.1 A prepared sample of coal of limited size range is ground under defined conditions in a laboratory mill of standardized design. The grindability index is calculated from sieve analysis of the ground product and a calibration chart prepared from standard reference coal.

4. APPARATUS

4.1 Balance

- a) Capacity 100 g, sensitivity 10 mg;
- b) Capacity 1 500 g, sensitivity 1 g.

*Rules for rounding off numerical values (*revised*).

†Glossary of terms relating to solid mineral fuels: Part I Terms relating to coal preparation.

‡Glossary of terms relating to solid mineral fuels: Part II Terms relating to coal sampling and analysis.

4.2 Crusher — A laboratory plate mill or a hand grinder capable of reducing 4.75 mm coal particles to 1.2 mm with the production of a minimum of material finer than 600 micron. The plates shall be serrated and shall be of about 100 mm in diameter. The distance between the plates shall be adjustable and the relative speed of rotation of the plates shall not exceed 200 rev/min. Roll or impact crushers shall not be used.

4.3 Sieves

- a) Wire cloth test sieves 1.18 mm, 600-micron and 75-micron with cover and receiver about 200 mm diameter, conforming to IS : 460-1962* or equivalent.
- b) Protective sieve (capable of nesting in the test sieves) with round or square hole apertures in the range 16 to 19 mm. A plate sieve with round holes is recommended.

4.4 Mechanical Sieving Machine — A machine capable of accepting an assembly of vertically nested sieves, cover and receiver of about 200 mm in diameter. The machine shall be able to simulate the motions of hand sieving. This may be achieved by imparting a horizontal oscillatory motion of 25 to 30 mm amplitude at rate of approximately 300 cycles per minute, while striking the top of the oscillating assembly at a rate of approximately 150 blows per minute by a mass of 1.9 kg moving through a vertical distance of about 25 mm under the influence of gravity. Alternatively, the nest of sieves, cover and receiver may be vibrated by an electromagnetic device, provided the sieving performance is equivalent to the mechanically vibrated machine described. Where mechanical sieving device is not available, an equivalent amount of hand sieving is necessary.

4.5 Grindability Machine — The machine is shown in Fig. 1 and the essential tolerances are shown in Fig. 1A. It includes a stationary grinding bowl, of hardened iron or steel, with a horizontal track in which run eight steel balls, each 25.400 ± 0.003 mm diameter. The balls shall be driven by an upper grinding ring rotated at 19 to 21 rev/min. The upper grinding ring of similar material to the bowl, is connected to a spindle and shall be driven by an electric motor through reduction gears. Weights shall be added to the spindle so that the total vertical force on the balls due to the top ring, gear, weights and spindle is 284 ± 2 N, for example, closely equivalent to a total mass of 29 ± 0.2 kg. The machine shall be fitted with a revolution counter and an automatic device for stopping the machine after 60 ± 0.25 revolutions. It shall be calibrated by the method described in 7 before use for the determination of Hardgrove indices.

NOTE — The grinding bowl, balls and top grinding ring should be protected from rusting when not in use by storing in a desiccator with silica gel.

*Specification for test sieve (revised).

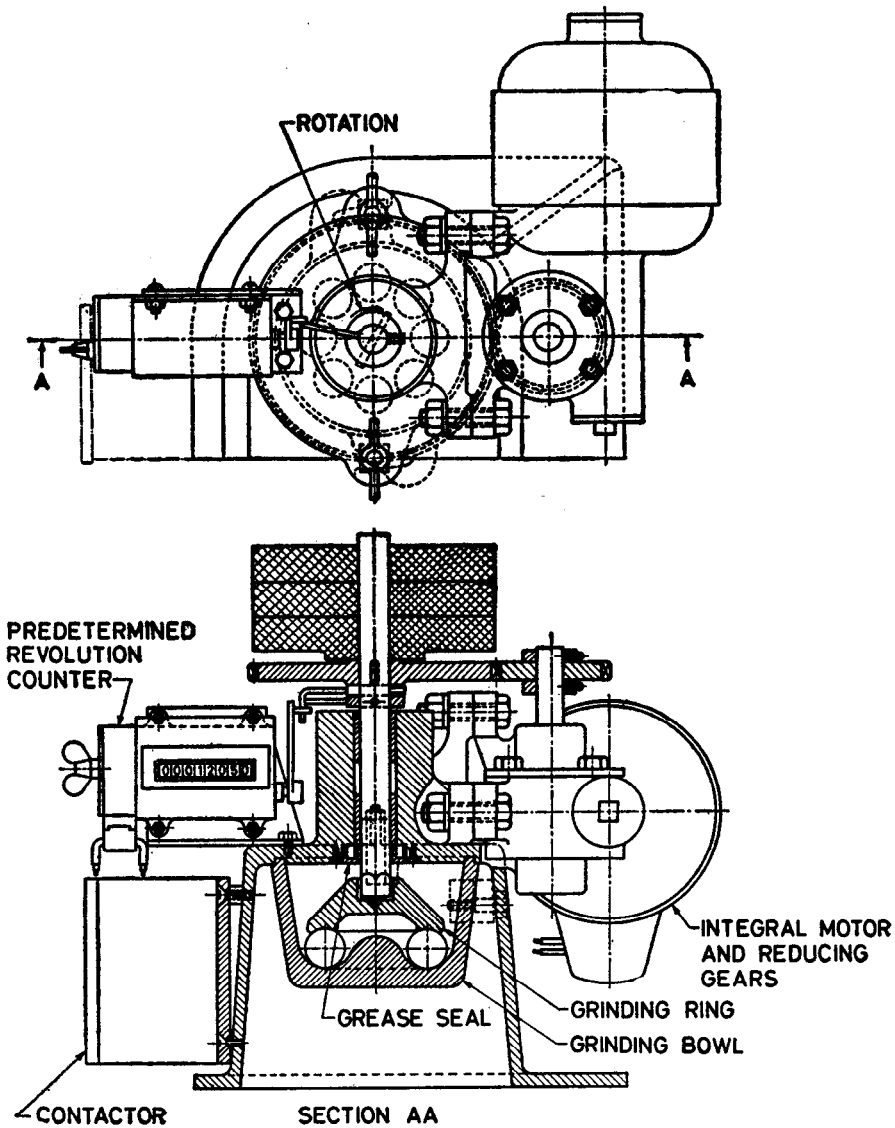
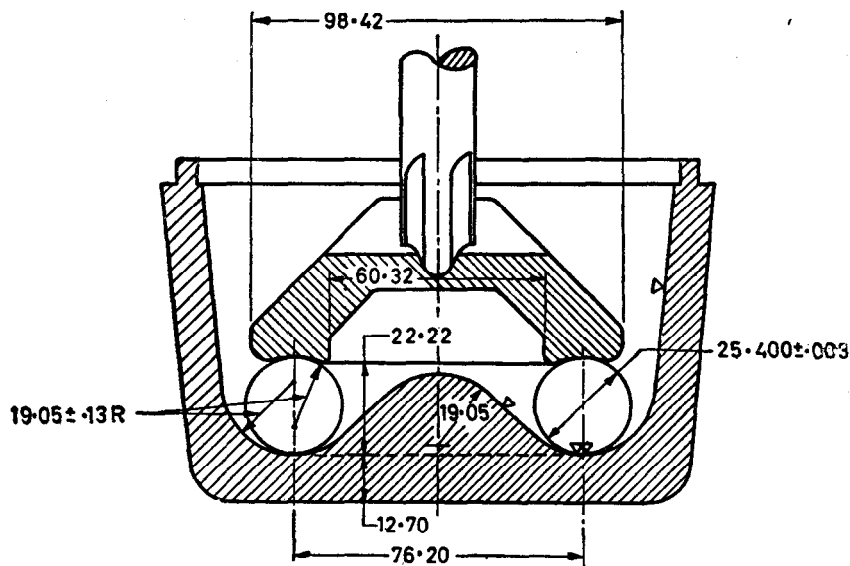


FIG. 1 HARDGROVE GRINDABILITY MACHINE



▽ Smooth machined surface
 ▽▽ Fine machined surface

All dimensions in millimetres.

FIG. 1A DETAILS OF GRINDING ELEMENTS OF HARDGROVE MACHINE

5. SAMPLING

5.1 The collection of the gross sample and its preparation shall be in accordance with IS : 436 (Part I/Sec 1)-1964*, except that the initial crushing shall be to 4.75 mm instead of 10 mm. Reduce the quantity of 4.75-mm coal to about 1 kg by using a sample divider of suitable size and capacity.

6. SAMPLE PREPARATION

6.1 Air dry 1 kg portion of 4.75-mm coal between 24 hours and 48 hours. Determine the mass of the dried portion to the nearest gram. Sieve the entire amount on a set of nested sieves consisting of a 1.18-mm IS Sieve

*Methods for sampling of coal and coke: Part I Sampling of coal, Section 1 Manual sampling (revised).

on top of a 600-micron IS Sieve by sieving batches of about 200 g for 2 minutes in the sieving machine. Crush the material retained on the 1·18-mm sieve with the crusher adjusted so that only the largest particles are crushed. Sieve the crushed material for 2 minutes and return the oversize to the crusher, again set to crush only the largest particles. Continue crushing and sieving until all the material passes through the 1·18-mm sieve.

6.2 Discard that part of the portion passing through the 600-micron sieve. Weigh to the nearest gram the coal passing the 1·18-mm sieve and retained on the 600-micron sieve. If the yield in this size range is less than 50 percent of the dried portion, the coal thus prepared shall be discarded and the sample preparation shall be repeated starting with another 1 kg portion of the 4·75-mm coal.

6.3 Mix thoroughly the 1·18-mm by 600-micron size coal. Remove about 120 g using a sample divider and de-dust by sieving for 5 minutes on a 600-micron sieve using the sieving machine. Reduce the de-dusted material, using a sample divider, to not less than 50 g.

7. TEST PROCEDURE

7.1 Clean the grindability machine thoroughly and space the balls as evenly as possible around the grinding bowl.

7.2 Weigh 50 ± 0.01 g of the de-dusted material as prepared in 6, distribute this evenly in the grinding bowl, and smoothen the surface. Assemble the top grinding ring to the bowl, fasten the bowl in position to the driving spindle making sure that the load is evenly applied. Preset the counter and adjust the automatic stopping device so that the machine can operate for 60 ± 0.25 revolutions. Start the apparatus.

7.3 When the rotation has stopped, switch off the machine and dismantle the bowl assembly. Brush any adherent coal dust on to the protective sieve nested on the 75-micron sieve and receiving pan. Empty the grinding balls and ground coal on to the protective sieve (*see Note*). Brush any coal from the bowl and the balls into the protective sieve, setting them aside. Brush any coal and dust from the inside and underside of the protective sieve into the 75-micron sieve and set it aside.

NOTE — The 16-micron or 20-micron sieve used to protect the 75-micron sieve may be distorted by use and become unsuitable for testing sieving purposes. It should be marked accordingly.

7.4 Replace the cover on the 75-micron sieve. Shake the assembled pan, 75-micron sieve and cover for 10 minutes. Carefully brush any coal dust from the underside of the 75-micron sieve into the pan. Repeat the sieving for two more periods of shaking, each of 5 minutes, cleaning the underside of the 75-micron sieve after each repetition.

7.5 Weigh separately to the nearest 0.01 g of the coal retained on the 75-micron sieve and the coal passing the 75-micron sieve. If the sum of these masses differs by more than 0.3 g from the initial mass of 50 ± 0.01 g, the test shall be rejected.

8. CALCULATION AND REPORTING OF RESULTS

8.1 Calculate the Hardgrove grindability index using the formula:

$$\text{HGI} = 13 + 6.93 M$$

where

M = mass of the test sample passing through 75-micron sieve after grinding. In practice M is obtained by deducting from 50 g the mass of the ground sample retained on 75-micron sieve.

8.2 Carry out duplicate determinations on portions taken from the 1.18 mm by 600-micron fraction. Report the mean grindability index rounded to the nearest whole number. Also read the Hardgrove grindability index against the range of mass from Table 1.

9. PRECISION

9.1 Repeatability — The results of duplicate determinations carried out at different times in the same laboratory by the same operator with the same apparatus, on portions of the same lot of 1.18 mm by 600-micron coal, shall not differ by more than 2 units.

9.2 Reproducibility — The means of the results of duplicate determinations carried out in each of two different laboratories on portions of the same lot of 4.75-mm coal, shall not differ by more than 3 units.

**TABLE 1 STANDARD TABLE FOR ASCERTAINING VALUES OF HGI
FROM THE EXPERIMENTAL VALUES OF MASS OF THE
COAL PARTICLES OVER 75-MICRON SIEVE**

(Clause 8.2)

| RANGE OF MASS IN GRAM | HGI | RANGE OF MASS IN GRAM | HGI |
|--------------------------|-----|--------------------------|-----|
| 39·0000-39·1053 ... | 89 | 42·8572-43·0014 ... | 62 |
| 39·1054-39·2496 ... | 88 | 43·0015-43·1457 ... | 61 |
| 39·2497-39·3939 ... | 87 | 43·1458-43·2900 ... | 60 |
| 39·3940-39·5382 ... | 86 | 43·2901-43·4343 ... | 59 |
| 39·5383-39·6825 ... | 85 | 43·4344-43·5786 ... | 58 |
| 39·6826-39·8268 ... | 84 | 43·5787-43·7229 ... | 57 |
| 39·8269-39·9711 ... | 83 | 43·7230-43·8672 ... | 56 |
| 39·9712-40·1154 ... | 82 | 43·8673-44·0115 ... | 55 |
| 40·1155-40·2597 ... | 81 | 44·0116-44·1558 ... | 4 |
| 40·2598-40·4040 ... | 80 | 44·1559-44·3001 ... | 53 |
| 40·4041-40·5483 ... | 79 | 44·3002-44·4444 ... | 52 |
| 40·5484-40·6926 ... | 78 | 44·4445-44·5887 ... | 51 |
| 40·6927-40·8369 ... | 77 | 44·5888-44·7330 ... | 50 |
| 40·8370-40·9812 ... | 76 | 44·7331-44·8773 ... | 49 |
| 40·9813-41·1255 ... | 75 | 44·8774-45·0216 ... | 48 |
| 41·1256-41·2698 ... | 74 | 45·0217-45·1659 ... | 47 |
| 41·2699-41·4141 ... | 73 | 45·1660-45·3102 ... | 46 |
| 41·4142-41·5584 ... | 72 | 45·3103-45·4545 ... | 45 |
| 41·5585-41·7027 ... | 71 | 45·4546-45·5988 ... | 44 |
| 41·7028-41·8470 ... | 70 | 45·5989-45·7431 ... | 43 |
| 41·8471-41·9913 ... | 69 | 45·7432-45·8874 ... | 42 |
| 41·9914-42·1356 ... | 68 | 45·8875-46·0317 ... | 41 |
| 42·1357-42·2799 ... | 67 | 46·0318-46·1760 ... | 40 |
| 42·2800-42·4242 ... | 66 | 46·1761-46·3203 ... | 39 |
| 42·4243-42·5686 ... | 65 | 46·3204-46·4646 ... | 38 |
| 42·5686-42·7128 ... | 64 | 46·4647-46·6089 ... | 37 |
| 42·7129-42·8571 ... | 63 | | |